



A.D. 1865, 6th JULY. N° 1784.

Electric Telegraphs.

LETTERS PATENT to William Thomson, of Glasgow College, Doctor of Laws and Professor of Natural Philosophy in the University and College of Glasgow, and Cromwell Fleetwood Varley, of Fleetwood House, Beckenham, in the County of Kent, for the Invention of "IMPROVEMENTS IN ELECTRIC TELEGRAPHHS."

Sealed the 22nd December 1865, and dated the 6th July 1865.

PROVISIONAL SPECIFICATION left by the said William Thomson and Cromwell Fleetwood Varley at the Office of the Commissioners of Patents, with their Petition, on the 6th July 1865.

We, WILLIAM THOMSON, of Glasgow College, Doctor of Laws and Professor of Natural Philosophy in the University and College of Glasgow, and CROMWELL FLEETWOOD VARLEY, of Fleetwood House, Beckenham, in the County of Kent, do hereby declare the nature of the said Invention for "IMPROVEMENTS IN ELECTRIC TELEGRAPHHS," to be as follows:—

This Invention has for its object improvements in electric telegraphs. In order to transmit signals of short duration through long submarine telegraphic lines with great rapidity and distinctness, we arrange apparatus in such manner that each time the operator puts down a finger key, or acts on an instrument equivalent to a finger key, the apparatus will automatically send

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into the line in rapid succession three or a greater number of currents of equal strength alternately positive and negative, but of unequal duration. The first current corresponds in sign with that which it is desired should arrive at the other end of the line, the second is of opposite sign, and the third is of the same sign as the first current. When three currents are 5 employed to produce one signal the duration of the second current should exceed that of the first, and the duration of the third current should be less than that of either the first or second. If more than three currents are employed to produce a single current and signal at the distant end of the line, the fourth current will be opposite in sign to the third, the fifth opposite to 10 the fourth, and so on. The first current sent causes a rapid change in the electrical state of the conductor, but if it were alone and uncorrected it would on arriving at the distant station occupy the receiving instrument for a considerable time, and produce on it a stronger effect than is desired ; therefore, to cut it off (so to speak), and leave only the effect required, electricity of 15 opposite sign is thrown into the wire, and in order that this second current may have power to operate as rapidly as possible in overcoming the first current, the second current is continued on so long that if uncorrected it would produce an effect beyond that required of it in checking the first current, and so the second current is in turn corrected by a third current, and 20 this again may be corrected by a fourth, and so on theoretically to any number ; but from five to seven currents are, we believe, as many as are practically required in such a cable as the present Atlantic. Whatever be the number of currents employed to produce a single indication, it is essential that the currents which correspond in sign with the single current which is desired 25 to arrive at the distant station should in the sum of their durations exceed the currents of opposite sign. If it be desired to produce at the distant end of the line a signal of some duration, corresponding with say a line in Morse's alphabet, it may be done on the same principle by increasing the duration of the several currents and somewhat altering their proportions, thus an indica- 30 tion of greater strength and somewhat longer duration is obtained ; or without increasing the strength of the indication its duration may be prolonged by introducing a series of rapidly alternating currents so proportioned as to maintain the current at the distant end of the strength required. Thus it will be seen that a transmitting instrument may be constructed to send into a tele- 35 graphic line combined currents as above described suitable to give at the further end of the line four distinct signals, viz., 1, a feeble signal of short duration and positive sign ; 2, a similar signal of negative sign ; 3, a signal of greater strength or duration, or both, and positive sign ; and 4, a signal similar

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to that last mentioned and negative in sign. Similarly an instrument may be made to give combined currents for signals of three or even a greater number of different strengths or durations.

We prefer to arrange the instrument for sending these or similar successive 5 sions of currents automatically at the required intervals in the following manner:—The apparatus consists of an axle driven as nearly as may be at a uniform rate, and it carries one or more cams, and each cam is free to move on the axle. On the axle there are (for each cam) two discs of metal, and on the cam a disc of similar size. A spring presses the disc on the cam 10 against one of the discs fixed on the moving axle. Between these discs a piece of oiled leather or other suitable material is placed so that the cam is driven by friction, and its stoppage does not stop the rotation of the axle. A detent by falling into a notch prevents the cam from rotating. The other end of the spring before mentioned that presses the cam also presses against a 15 disc whose edge is cut into the form of a ratchet wheel. This latter disc is separated from the fixed disc on the axle also by a disc of oiled leather. There is a second detent taking into the teeth of this wheel, and so arranged that when the former detent is lifted the latter detent falls into the ratchet wheel. Thus the friction opposing the motion of the machine is equalized so 20 as to remain nearly the same whether the cam be running or not. Or this method of equalizing the friction may be dispensed with if a sufficiently powerful governor be applied in connection with the rotating axis. When the key is pressed down the detent is lifted and the cam rotates until the key is lifted and the cam has returned to its starting point, assuming that one revolution 25 of the cam corresponds with one signal (because in some instances it becomes advisable to use half or other submultiple of the revolution of the cam to produce a signal). This cam either carries a number of properly insulated contact pieces or projections acting upon springs or levers by which in moving through one revolution or submultiple of a revolution as aforesaid 30 it produces alternately contacts of varying lengths as already mentioned. The precise lengths of these contacts depend upon the length of the line to be worked and many other conditions. If it be desired to work with an alphabet on the Stenheil principle one cam only may be used with two keys and a current reverser, so that in pressing down the right-hand key such 35 signals are produced as will correspond to say a positive current at the distant end of the line, while if the left-hand key be pressed down the connections being reversed, currents of similar duration but opposite names are sent through the line to produce a negative signal at the distant end. Also if it is desired the strength of these signals may be varied by varying

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the battery power ; for this purpose four keys may be combined with one cam, two keys working with the feeble power and giving positive and negative signals respectively, and the other two keys working similarly with the stronger battery power. If it is desired to work with an alphabet on the Morse principle, two keys are employed, one key releases a cam which produces a dot, the other key releases another cam which produces a dash, and in this case, and generally where it is desired to give signals of different durations, the cams should be on different axes with different speeds of rotation, or some equivalent arrangement should be resorted to, and mechanism should also be applied, so that when a key of any cam is down no other key can go down. A spring or click may be combined with each cam in such manner that when the cam revolves it lifts the spring or click by a snail on the cam so as to give audible notice when the rotation of the cam is nearly completed by dropping off the end of the snail, and this informs the operator when he may begin to make a fresh signal ; or other equivalent mechanism may be employed to give this audible notice. The speed of the machine is controlled by a fly or other suitable appliance to produce a rate of rotation as uniform as may be. In place of arranging the cams to travel intermittently, they may be kept revolving continuously but without sending currents into the telegraphic line until the key is depressed and the apparatus connected with the key is so arranged that at whatever time during the rotation of the axis the key is put down, it commences to act only at the starting point of the cam, and continues to act until all the currents required for the signal have been sent into the line. In some cases we allow the cams to act continuously on their springs or levers, and then the key acts to put the springs or levers belonging to its cam into the telegraphic circuit at the commencement of the signal and to take them out at the end thereof ; or the springs or levers may be kept out of contact with the cams except when their keys are depressed ; in this latter case the same operation of throwing the train of contacts for the particular cam into the telegraphic circuit ought to be performed as in the first case, to obviate the objection of leaving more contacts in the telegraphic circuit than necessary. If desired the cams may be so constructed as each to send into the line combined currents suitable to produce two or more currents at the distant station, for instance so as to indicate a particular letter corresponding with the key employed. Also in place of cams it is evident that cylinders to receive moveable type, like projections may be employed, or type may be assembled on a flat surface having a motion given to it to carry the type under springs or levers such as those on which the cams are described to act. Each type will have several projections on it suitable for sending into the

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telegraphic line combined currents such as to produce either one, two, or several currents at the distant end of the line.

We would remark that in the Specification of a former Patent granted to one of us, viz., to me the aforesaid William Thomson, bearing date the 5. 20th February, 1858, No. 529, there is described methods of producing signals through a long submarine telegraphic line which are to some extent analogous to those herein-before described. According to one of these methods a signal was produced by sending into the line wire for a given time, say for one second, a current of a certain strength (call it 48) then for another 10 second there was sent into the line wire a current of opposite sign, of greater strength, say 50, and lastly for a third second there was sent into the wire a current of the same sign as the first, with a strength of say 12. In this way the result required was approximately obtained, but the method is inconvenient requiring as it does the use of three different strengths of electricity besides 15 which the use of the weaker currents involves a loss of time. There is also a simpler arrangement described in the same Specification ; it consists in sending first a current of the same sign as that which is intended to arrive at the further end of the line, and then another current of opposite sign and the same strength, but continued for a shorter time so as to neutralize 20 the excess of the first current. This method is simple, and to some extent accomplishes its object, but it will not give a speed equal to that given by the method herein-before described where the duration of the second current exceeds that required to neutralize the excess of the first, and a subsequent compensation is made by the use of another current or currents. We would 25 further remark that three is the greatest number of currents ever heretofore employed to produce a single indication, and that with very slow cables a much better effect is obtained by employing according to our Invention apparatus for sending into the telegraphic line four, five, or a greater number of currents to produce a single indication.

30 **SPECIFICATION** in pursuance of the conditions of the Letters Patent, filed by the said William Thomson and Cromwell Fleetwood Varley in the Great Seal Patent Office on the 6th January 1866.

TO ALL TO WHOM THESE PRESENTS SHALL COME, we, WILLIAM THOMSON, of Glasgow College, Doctor of Laws and Professor of Natural 35 Philosophy in the University and College of Glasgow, and CROMWELL FLEETWOOD VARLEY, of Fleetwood House, Beckenham, in the County of Kent, send greeting.

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WHEREAS Her most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the Sixth day of July, in the year of our Lord One thousand eight hundred and sixty-five, in the twenty-ninth year of Her reign, did, for Herself, Her heirs and successors, give and grant unto us, the said William Thomson and Cromwell Fleetwood Varley, Her special licence that we, the said William Thomson and Cromwell Fleetwood Varley, our executors, administrators, and assigns, or such others as we, the said William Thomson and Cromwell Fleetwood Varley, our executors, administrators, and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an Invention for "IMPROVEMENTS IN ELECTRIC TELEGRAPHS," upon the condition (amongst others) that we, the said William Thomson and Cromwell Fleetwood Varley, our executors or administrators, by an instrument in writing under our or their hands and seals, or under the hand and seal of one of us or them, should particularly describe and ascertain the nature of the said Invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said Letters Patent.

NOW KNOW YE, that I, the said Cromwell Fleetwood Varley, on behalf of myself and the said William Thomson, do hereby declare the nature of the said Invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement thereof, that is to say:—

This Invention has for its object improvements in electric telegraphs.

In order to transmit signals of short duration through long submarine telegraphic lines with great rapidity and distinctness, we arrange apparatus in such manner that each time the operator puts down a finger key or acts on an instrument equivalent to a finger key, the apparatus will automatically send into the line in rapid succession three or a greater number of currents of equal strength alternately, positive and negative, but of unequal duration. The first current corresponds in sign with that which it is desired should arrive at the other end of the line, the second is of opposite sign, and the third is of the same sign as the first current. When three currents are employed to produce one signal the duration of the second current should exceed that of the first, and the duration of the third current should be less than that of either the first or second. If more than three currents are employed to produce a single current and signal at the distant end of the line, the fourth

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current will be opposite in sign to the third, the fifth opposite to the fourth, and so on. The first current sent causes a rapid change in the electrical state of the conductor, but if it were alone and uncorrected it would on arriving at the distant station occupy the receiving instrument for a considerable time, and produce on it a stronger effect than is desired, therefore to cut it off (so to speak) and leave only the effect required, electricity of opposite sign is thrown into the wire, and in order that this second current may have power to operate as rapidly as possible in overcoming the first current, the second current is continued on so long that if uncorrected it would produce an effect beyond that required of it in checking the first current, and so the second current is in turn corrected by a third current, and this again may be corrected by a fourth, and so on theoretically to any number, but from five to seven currents are we believe as many as are practically required in such a cable as the present Atlantic. Whatever be the number of currents employed to produce a single indication it is essential for perfect compensation that the currents which correspond in sign with the single current which is desired to arrive at the distant station should in the sum of their durations exceed the currents of opposite sign. We prefer to arrange the instrument for sending these or similar successions of currents automatically at the required intervals in the following manner:—The apparatus consists of an axle driven as nearly as may be at a uniform rate, and it carries one or more cams, and each cam is free to move on the axle. On the axle there are (for each cam) two discs of metal, and on the cam a disc of similar size, a spring presses the disc on the cam against one of the discs fixed on the moving axle, between these discs a piece of oiled leather or other suitable material is placed, so that the cam is driven by friction, and its stoppage does not stop the rotation of the axle, a detent by falling into a notch prevents the cam from rotating. The other end of the spring before mentioned that presses the cam also presses against a disc whose edge is cut into the form of a ratchet wheel; this latter disc is separated from the fixed disc on the axle also by a disc of oiled leather. There is a second detent taking into the teeth of this wheel, and so arranged that when the former detent is lifted the latter detent falls into the ratchet wheel; thus the friction opposing the motion of the machine is equalized so as to remain nearly the same whether the cam be running or not; or this method of equalizing the friction may be dispensed with if a sufficiently powerful governor be applied in connection with the rotating axis. When the key is pressed down the detent is lifted and the cam rotates until the key is lifted, and the cam has returned to its starting point, assuming that one revolution of the cam corresponds with one signal

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(because in some instances it becomes advisable to use half or other sub-multiple of the revolution of the cam to produce a signal). This cam either carries a number of properly insulated contact pieces or projections acting upon springs or levers, by which in moving through one revolution or sub-multiple of a revolution as aforesaid it produces alternately contacts of varying lengths as already mentioned. The precise lengths of these contacts depends upon the length of the line to be worked, and many other conditions. A spring or click may be combined with each cam in such manner that when the cam revolves it lifts the spring or click by a snail on the cam so as to give audible notice when the rotation of the cam is nearly completed by dropping off the end of the snail, and this informs the operator when he may begin to make a fresh signal, or other equivalent mechanism may be employed to give this audible notice. The speed of the machine is controlled by a fly or other suitable appliance to produce a rate of rotation as uniform as may be. If it be desired to work with an alphabet or the Steinheil principle one cam only may be used with two keys and a current reverser, so that in pressing down the right-hand key such signals are produced as will correspond to, say, a positive current at the distant end of the line, while if the left-hand key be pressed down, the connections being reversed, currents of similar duration but opposite names are sent through the line to produce a negative signal at the distant end.

The accompanying Drawing shows the instrument we employ to send Steinheil signals, that is to say, simple, positive, and negative signals of equal duration and strength. The axle A, A¹, is driven as nearly as may be at a uniform rate, and carries a cam B free to move on the axle. On the axle A, A¹, there are two discs of metal, C and C¹, and on the cam there is a corresponding disc D ; a spring F presses the disc D of the cam against the disc C, which is fixed on the moving axle. Between these discs a piece of oiled leather or other suitable material is placed, so that the cam is driven by friction, and its stoppage does not stop the rotation of the axle. A detent G, (Figures 1, 2, and 8) by falling into a notch g, prevents the cam from rotating. The other end of the spring F before mentioned presses against a disc R, bearing the ratchet wheel a (Figures 1, 4, and 9). The disc R and ratchet are loose on the axle A, A¹, and are separated from the fixed disc C¹ on the axle also by a disc of oiled leather. There is a detent b taking into the teeth of the wheel a, and so arranged that when the detent G is lifted free from the notch g, the detent b enters the teeth of the ratchet wheel a. To effect this the levers forming the detents G and a are pinned to an axle c, d, as shown in the Drawing, so that b and G rise and fall together ; thus the friction

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opposing the motion of the machine is equalized, whether the cam be running or not, for if the cam be stopped there is a retarding friction between C and D, due to the pressure of the spring F, but no friction between a and C¹, but if the cam is running an equal friction occurs between a and C¹, but none 5 between C and D. The friction of the ends of the spring F is also equal in the two cases. This method of equalizing the friction may be dispensed with if a sufficiently powerful governor be applied in connection with the rotating axis. When either the vulcanite key P or N corresponding to positive and negative signals is pressed down, the detent G is lifted and the cam B rotates 10 with the axle A, A¹, until the key is released, when the spring f (Figures 4 and 2) forces the detent G into its notch as soon as the cam has reached its original position. Each single revolution of the cam B makes one signal by means of the contacts produced by the double set of projections under the springs e¹ and l¹. The arrangement of those projections is shown in Figures 5 15 and 6, and the order in which they act is indicated by the numerals 1, 2, 3, 4, 5, marked upon them. The projections in Figure 5 are under the spring l¹, and those in Figure 6 under e¹, each spring carries a small insulating wedge i, by which the projections on B alternately lift l¹ and e¹. The ends of these springs are furnished with platinum contact pieces which move between the 20 four contacts 1, 2, 3, and 4; the spring l, l¹, is connected with the line by the terminal L, the spring e, e¹, is connected with earth by the terminal E. The contacts 1 and 2 are in electrical connection with one another, and with a commutator at H and H¹ (Figures 2 and 3); the contacts 3 and 4 are in electrical connection with one another, and with 25 another part of the commutator J and J¹. When the key P is depressed the commutator is in the position shown in Figure 3, and the positive pole of the battery connected with contacts 1 and 2 by means of the terminal K, the axis k and arm k¹ of the commutator, and the contact plate H, which is directly joined to 1 and 2, at the same time the negative 30 pole of the battery is in connection with contacts 3 and 4 by means of the terminal Z, the axis z, and the arm z¹ of the commutator, and the contact plate J¹, which is directly joined to the contact pieces 3 and 4. The depression of the key P raises the detent G, and releases the cam B, which begins to revolve, while the ratchet a is at the same moment stopped by the 35 detent G. The two springs l¹ and e¹ at first remain both in contact with the contacts 3 and 4, placing the line and negative pole of the battery in connection with the earth, while the positive pole is insulated. When the cam has revolved a sufficient distance to have acquired the full velocity of the axis A, A¹, the projection x of cam B (Figures 2 and 5) lifts the spring l¹

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against contact 1, thus putting the positive pole of the battery to the line, and leaving the negative pole connected with the earth. Thus a positive current is poured into the line for a fraction of the time of revolution of A, A¹, depending on the length of the projection x . At the instant that the spring l^1 falls back to contact 3 on leaving the projection x , the spring e^1 is lifted to 5 contact 2 by the projection y (Figures 2 and 6), and a negative current is thus poured into the line for a fraction of the time of a revolution of A, A¹, longer than that occupied by the previous positive current. A second positive current enters the line when the projection z lifts the spring l^1 against contact 1 at the moment that e^1 falls back to 4. A second negative current is sent by 10 the projection u , and a third positive current by the projection v ; after this projection has passed under the wedge i of spring l^1 both l^1 and e^1 fall back to contacts 3 and 4, and again place the line in contact with the earth. This succession of contacts produces a single positive dot at the receiving end of the cable. If during the revolution of A, A¹, the key P has been released, the 15 detent G will fall into the notch g , the cam B will be arrested, the ratchet released, and no further currents will be sent. If the key be again depressed the same series of contacts will be repeated, and a second positive signal sent. If, however, after the completion of the last positive current sent by projection v the key N be depressed the cam will revolve as before, but as the 20 bar k^1 of the commutator will have been moved to J, and the bar z^1 to H¹, the first, third, and fifth currents which enter the line will now be negative; and the second and fourth will be positive; this succession of currents will give a single negative signal. Thus the depression of the keys P and N will 25 give any succession or combination of positive and negative signals, each produced by five currents, the relative lengths of which depend on the projections x, y, z, u, v , of the cam B. The spring or click O is lifted at each revolution of the cam B by the snail Q, fixed to the cam in such a position that when the projection v has just completed the last current contact for any signal the spring O drops off the projecting portion of the snail at q , and gives 30 an audible click, by which the operator is informed that one signal is complete, and that he may now begin to make a fresh signal. Confusion in the contacts would arise if the commutator were reversed by a change of keys before this click were heard.

The instrument shown in the Drawing, when properly adjusted, gives 35 successive contacts of about the following durations:—+ 100 — 156 + 80 — 32·5 + 26, the signs being such as they would be in making a positive signal, and after the contacts the cable may be connected with the earth for a short time before another signal is given; this the instrument it will be

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observed is arranged to do. These contacts are well adapted for a line similar to the Atlantic cable as now constructed. It is intended that the resulting current or shock arriving at the further end of the cable in consequence of each succession of contacts should be of a maximum strength of 5 somewhat less than one per cent. or more of the current which the battery employed in working the telegraph would be able to maintain through the cable were it connected with it for an indefinite time. The speed at which the axle A should be driven will be from 100 to 120 revolutions per minute, but the best speed can be found by experiment, and will be that at which the 10 currents or shocks obtained at the further end are somewhat less than one per cent. of the current the battery is able to produce, as before mentioned.

In order to enable an electrician to adapt the contacts to the requirements of different cables and instruments, the following information will be found useful:—It will be necessary for him first to determine according to his 15 judgment what proportional strength the working shocks or currents should bear to the current which the battery employed would be able to cause to pass through the cable if connected with it for a considerable time; this proportion will depend principally on the receiving instrument; for long and slow lines very sensitive receiving instruments will usually be employed, and 20 the proportional strength of the currents or shocks will be very small, whilst for shorter and quicker lines the receiving instruments do not require to be so sensitive, and the proportional strength of the currents or shocks to work them will have to be greater. If the electrician determine that about a one per cent. current or shock is necessary he may use the contacts of the 25 instrument shown in the Drawings, and he will adjust the working speed of the machine until he finds by experiment that about one per cent. currents or shocks are obtained. If a five per cent. current or shock is desired the contacts may be as follows:— $+ 0.7 - 1.14 + 0.7 - 0.26 + 0.06$; with this combination no earth connection is theoretically necessary, so that the total 30 duration of the signal will be 2.86 ; or a five per cent. current may be obtained with three contacts, thus:— $+ 0.7 - 1.05 + 0.4$; earth contact 1.0 ; total duration, 3.15 ; or $+ 0.63 - 0.83 + 0.27$; earth contact 1.5 ; total duration 3.23 (this last is somewhat less than a five per cent. signal). The unit of time is the same in each of these signals (with the exception of the 35 one per cent. signal), so that the advantage in speed obtained by using five contacts in place of three is evident. For a twenty per cent. current or shock the contacts may be (in the same units) $+ 1.52 - 1.76 + 0.66$; with this combination no earth contact is necessary, and the total duration is 3.94 units. The actual working speed of the machine will in each case be adapted

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by experiment to the line to be worked, as already explained. One or other of the examples above given will be found to suit approximately any ordinary long telegraphic cable, but in some cases the electrician may be able to make a nearer approximation to the requirements of a particular case by observing that as the strength of the current or shock required becomes less (as compared with the current the battery is able to pass through the cable) so the total duration of the positive and negative contacts becomes more nearly equal. If it be desired to produce at the distant end of the line, in addition to short signals such as already described, signals of some duration corresponding with, say a line in Morse's alphabet, it may be done on the same principle by increasing the duration of the several currents, and somewhat altering their proportions; thus an indication of greater strength and somewhat longer duration is obtained; for example, a 20 per cent. contact may be used for the long signals, whilst five per cent. contacts are employed for the short and small signals; or without increasing the strength of the indication its duration may be prolonged by introducing a series of rapidly alternating currents so proportioned as to maintain the current at the distant end of the strength required; this, however, is not usually so convenient. Thus it will be seen that a transmitting instrument may be constructed to send into a telegraphic line combined currents, as above described, suitable to give at the further end of the line four distinct signals; viz., 1, a feeble signal of short duration and positive sign; 2, a similar signal of negative sign; 3, a signal of greater strength or duration, or both, and of positive sign; and, 4, a signal similar to that last mentioned, and negative in sign. Similarly an instrument may be made to give combined currents for signals of three or even a greater number of different strengths or durations. Also, if it is desired, the strength of the signals may be varied by varying the battery power; for example, in an instrument such as is shown in the Drawing four keys may be combined with one cam, two keys working with the feeble power, and giving positive and negative signals respectively, and the other two keys working similarly with the stronger battery power. If it is desired to work with an alphabet on the Morse principle two keys are employed, one key releases a cam which produces a dot; the other key releases another cam which produces a dash, and in this case, and generally where it is desired to give signals of different durations, the cams should be on different axes, with different speeds of rotation, or some equivalent arrangement should be resorted to, such, for example, as making the shorter cam to do its work in half a revolution of the axis, whilst the longer cam takes a whole revolution; the shorter cam may in this case be made double to avoid loss of time. In place of arranging the cams to travel intermittently they may be kept revolving

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continuously, but without sending currents into the telegraphic line until the key is depressed, and the apparatus connected with the key is so arranged that at whatever time during the rotation of the axis the key is put down it commences to act only at the starting point of the cam, and continues to act 5 until all the currents required for the signal have been sent into the line ; the arrangement described is, however, preferred. Or the cams may act continuously on their springs or levers, and then the key acts to put the springs or levers belonging to its cam into the telegraphic circuit at the commencement of the signal, and to take them out at the end thereof ; or the springs or levers 10 may be kept out of contact with the cams, except when their keys are depressed ; these methods, however, are not superior to that which is described in detail. If desired the cams may be so constructed as each to send into the line combined currents suitable to produce two or more currents at the distant station, for instance, so as to indicate a particular letter corresponding with 15 the key employed. Also in place of cams it is evident that cylinders to receive moveable type-like projections may be employed, or type may be assembled on a flat surface having a motion given to it at a suitable speed to carry the type under springs or levers such as those on which the cams are described to act. Each type will have several projections on it suitable for sending into the 20 telegraphic line combined currents such as to produce either one, two, or several currents at the distant end of the line.

We would remark that in the Specification of a former Patent granted to one of us, vizt., to the aforesaid William Thomson, bearing date the 20th February 1858 (No. 529), there is described methods of producing signals 25 through a long submarine telegraphic line, which are to some extent analogous to those herein-before described. According to one of these methods a signal was produced by sending into the line wire for a given time, say for one second, a current of a certain strength (call it 48), then for another second there was sent into the line wire a current of opposite sign of greater strength, 30 say 50, and, lastly, for a third second there was sent into the wire a current of the same sign as the first, with a strength of, say, 12. In this way the result required was approximately obtained, but the method is inconvenient, requiring, as it does, the use of three different strengths of electricity ; besides which, the use of the weaker current involves a loss of time.

35 There is also a simpler arrangement described in the same Specification ; it consists in sending first a current of the same sign as that which is intended to arrive at the further end of the line, and then another current of opposite sign and the same strength, but continued for a shorter time, so as to neutralize the excess of the first current. This method is simple, and to some extent

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accomplishes its object, but it will not give a speed equal to that given by the method herein-before described, where the duration of the second current exceeds that required to neutralize the excess of the first and a subsequent compensation is made by the use of another current or currents.

We would further remark that three is the greatest number of currents ever heretofore employed to produce a single indication, and that with very slow cables a much better effect is obtained by employing according to our Invention apparatus for sending into the telegraphic line four, five, or a greater number of currents to produce a single indication.

It is obvious that although not so convenient it is possible to use four or a greater number of currents or shocks of unequal strength to produce a single indication, and the information given in this Specification will enable an electrician properly to proportion the durations of such currents or shocks, as it will be necessary only to follow the directions already given, with the exception of making suitable allowance for the strength of the currents or shocks which he is employing ; these proportions can also be adjusted by experiment.

What we claim is,—

First, the arranging telegraphic apparatus to send automatically into the circuit in rapid succession three or a greater number of currents or shocks of equal strength and properly proportioned, as described, to produce at the receiving end a single current or shock.

Second, we claim the arranging telegraphic apparatus to send automatically into the circuit four or a greater number of currents or shocks (of equal or unequal strengths), properly proportioned as described to produce at the receiving end a single current or shock.

Thirdly, we claim the arranging apparatus for transmitting electric currents into a telegraphic circuit, as herein-before described.

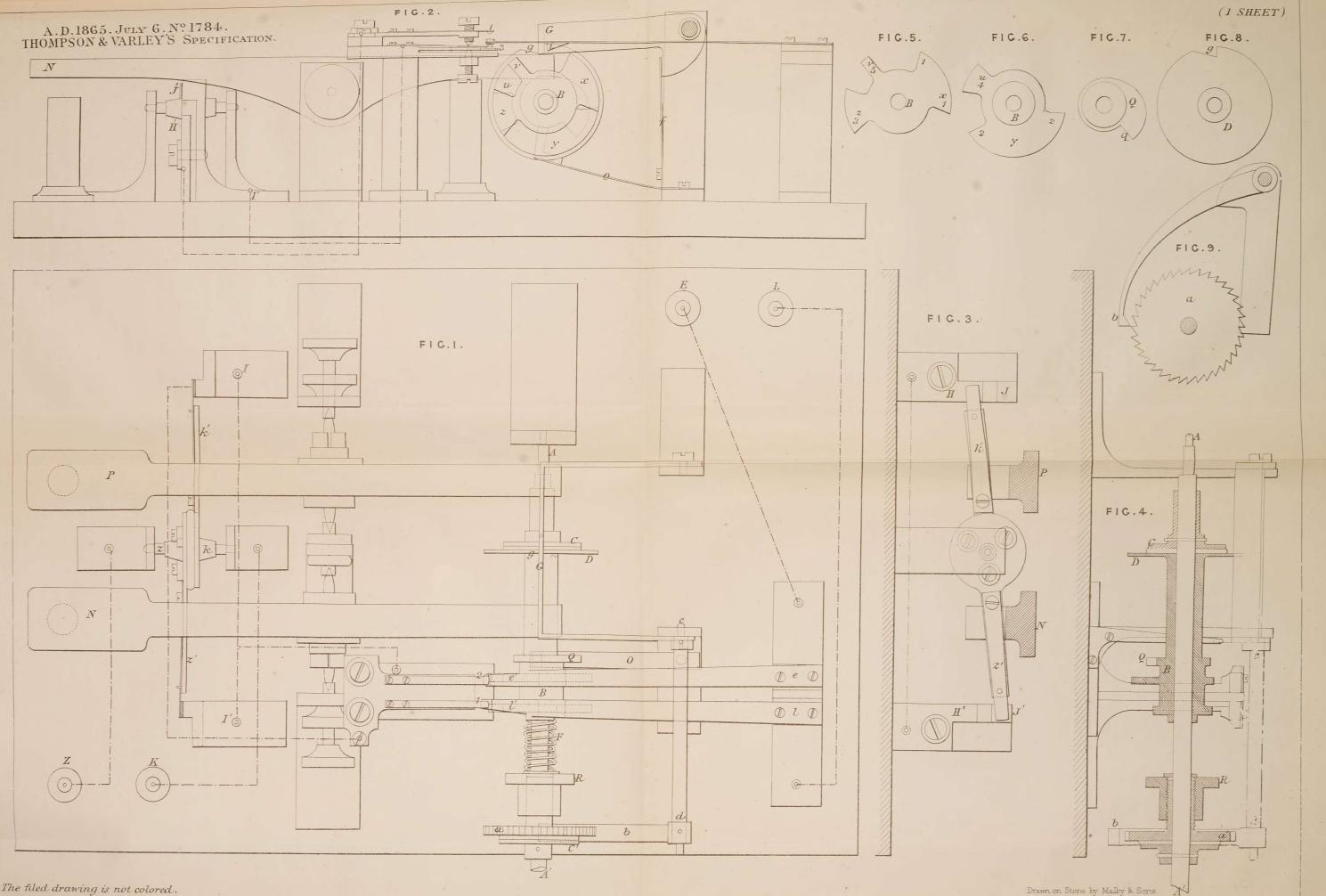
In witness whereof, I, the said Cromwell Fleetwood Varley, have hereunto set my hand and seal, this Fifth day of January, in the year 30 of our Lord One thousand eight hundred and sixty-six.

CROMWELL F. VARLEY. (L.S.)

LONDON :

Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty. 1866.

A.D.1865, JULY 6, N^o 1784.
THOMPSON & VARLEY'S SPECIFICATION.



The filed drawing is not colored.

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